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## *WEATHER AND CROPS.*

Temperatures ranged slightly below the seasonal average, but the effect of this thermal deficiency was offset, to a considerable extent, by several spells of sultry weather which occurred at intervals. At Honolulu, the mean daily departure from the normal temperature for June (average of two stations) was -1.3 degrees, the same as during the preceding month. Atmospheric pressure, wind direction, and wind velocity were about normal throughout the month.

Conditions throughout the month were, as a whole, very favorable for the growth of all cane, although high winds during the second and third weeks caused some slight damage to young cane. Good showers during the first week were of particular advantage in the Kau district of Hawaii, but by the close of the month conditions were quite dry again in that section, especially at the lower levels. Cane also suffered for lack of moisture in the Kipahulu district of Maui during the latter half of the month; during the same period it became necessary in central Maui to supplement the supply of ditch water by pumping. In windward Kauai the water supply available for irrigation purposes was rather low during nearly the entire month, but serious consequences were averted by heavy showers during the last decade. The grinding of mature cane continued, and was completed at a number of the mills during the month. Planting, cultivating and other field operations proceeded rapidly in all sections, but were interfered with to some extent in windward Hawaii during the second decade by excessively moist conditions which, however, were very favorable for the advancement of recently planted cane.

## *LEAF-HOPPERS AND THEIR NATURAL ENEMIES.*

(Pt. I. Dryinidae.)

By R. C. L. Perkins.

### INTRODUCTORY REMARKS.

The parasites considered in this Bulletin all belong to the Dryinidae, a family of insects which, so far as is known, confine their attacks to certain groups of the Homopterous Rhynchota, popularly known as leaf-hoppers. The material which has been studied is chiefly from two sources: (1) the species observed and collected by Mr. Koebele and myself in Queensland from June till the end of December, 1904, and (2) some of the species sent to these islands from Ohio and California by Mr. Koebele in 1903; to which may be added two species peculiar to these islands. With regard to the parasites sent from Ohio and California, those which I have described below by no means include all the species sent by Mr. Koebele, and probably few or none of the rare ones are represented. This is due to the fact that unless a considerable number of individuals were sent, I was unwilling to lose the chance of establishing a species in these islands by killing specimens for purposes of study. I now regret this fact, as had I made a critical study of these insects at that time, I should have found out what I now know, that many of the parasites sent by Mr. Koebele would not have been the least likely to accomplish the object for which they were sent, that is to attack the sugar cane leaf-hopper, since their structure is in certain respects quite different from that of those which attack leaf-hoppers of that group. From want of this knowledge much time and trouble were wasted in attempting the impossible; while several species sent, which were quite likely to attack the cane-hopper and to become established, suffered, accordingly for want of attention, when this should have been entirely centered on them. The material for study that has passed through my hands, dead or alive, has been very large. Mr. Koebele sent to Honolulu from Ohio and California (but far the greater part from the former State) some three thousand cocoons which produced several genera and many species. During the time these were being received, I bred many thousands of the Hawaiian *Echthrodelphax* for distribution in localities from which it was absent. In the six months spent in Australia, we reared a still greater number of species.

Indeed when one considers that Mr. Koebele's work in the United States was practically confined to two small areas; that nearly all our material from Australia was secured in two limited areas in Queensland, while we know that the Dryinidae are common and generally distributed in the tropics and temperate regions alike, and even occur naturally in Oceanic islands like Hawaii, it is clear that from an insignificant family with few species, this will in time become one of importance, comprising many genera and hosts of species. Particularly in Australia would the student reap a rich harvest, for it must be remembered that we were investigating these insects only during six months, and of this time only a fraction was specially devoted to them. Moreover, most of our work was done in cultivated districts, where cane is grown, or on land periodically burnt over, and greatly changed from its natural conditions, in fact such places as the entomologist bent on purely scientific research would naturally avoid. It is a remarkable fact that the student, and of course more particularly the collector of leaf-hoppers, should so rarely have noticed these parasites. One would suppose it almost impossible to collect Homoptera for a single day and not notice the conspicuous presence of the larval sac of some of the Dryinidae. They are, too, so extremely easy to breed in confinement, even under most unnatural conditions, such as in a small glass vial, that it is surprising how few have been recorded as bred.

A list of some of the later writings on this family is given below, but I have not thought it necessary to refer to those of Westwood, Walker and the old writers. References to these will be found in Ashmead's Monograph of the North American Proctotrupidae. The latter work I have studied very carefully in drawing up the characters of my new genera, and since most of the North American genera are unknown to me, and European material has not been procurable at all, I have been greatly indebted for information concerning these to the Monograph mentioned above, which includes most of the European genera.

Since that work was published, Dr. Ashmead has entirely changed his views as to the systematic position of the Dryinidae, placing them now with the true wasps, and altogether apart from the Procotrupids. I regret that I am not at all able to follow the learned American hymenopterist in his latest views on the classification of the wasps, nor with some of his views as to the structure of certain Dryinidae, nor with his conclusions as to the significance of their chelate tarsi. These points will be discussed below.

Since the greater part of this Bulletin was written, we have received a recent paper on the raptorial front legs of the Dryinidae by Dr. J. J. Kieffer, in which figures and descriptions of these are given. The figures illustrating the present Bulletin will be published later, with those illustrating other leaf-hopper parasites.

## GENERAL ACCOUNT OF THE DRYINIDAE.

### LIFE HISTORY OF ECHTHRODELPHAX AS TYPICAL OF THE DRYINIDAE.

When in 1903 for the purpose of distribution in the canefields many hundreds of *Echthrodelphax* were kept in a cage with glass sides and large enough to contain a fair-sized growing plant of sugar cane, on which large flocks of the larvae of the cane leaf-hopper were feeding, the habits of the parasite could be studied to great advantage. By having a cage thus well stocked with the parasites, one can insure the fact that at almost any time individuals may be seen in the act of catching their prey. In such a cage, on one occasion, I counted over thirty parasites on a single cane stem each one simultaneously engaged in stinging the young hopper it had seized. When the hoppers were excreting an abundance of honey-dew, the parasites fed freely on this, but if not, some sweet liquid was supplied in place of it. Without liquid food, in a hot locality the parasites die very quickly, and the cage was freely sprinkled with water each day to advantage. Pairing of the sexes is of short duration and after copulation the male frequently never moves again, and in general dies very quickly. To watch the female parasite stalking, catching and stinging its prey, is a most interesting sight. The prey is sought on foot, for while most of the Dryinidae are most active and rapid runners, they are but poor performers on the wing. In most of the winged forms, these organs are unduly short and in *Echthrodelphax* serve hardly more than to transport it from one cane plant to another as occasion demands. As soon as the parasite becomes aware of the presence of its prey, it usually comes to a standstill, while still at a short distance; it assumes a rigid attitude comparable with that of a dog pointing game; the antennae are laid back behind the head; frequently it sidles round the hopper to gain a more advantageous position for the attack. The hoppers often show manifest uneasiness on the approach of the parasite and they hasten to remove themselves to a distance, as the latter comes to a point. In this case they are again followed up, and the performance may be repeated several times. In some cases through too great deliberation in attack the prey is entirely lost, as it moves away into concealment and the parasite fails to trace it up.

Deliberate as it often is in making the attack, yet, when made, the stroke is marvelously rapid. So quickly indeed are the front legs thrown out and withdrawn that the hopper, which just now was at a distance, in an instant appears contiguous to the parasite, as if attracted by some unseen force. One pair of pincers usually grips the neck of the prey the other frequently clasps the pair of hind legs in the neighborhood of their long jumping spurs, or the abdomen towards the apex. If the hopper is unusually large and strong compared with its enemy, it not rarely manages to make its leap, and both fall to the ground together. Never however, was the latter seen to relinquish its hold on the former. Its prey firmly secured and frequently held more or less crosswise to itself, the parasite now curls round the abdomen and thrusts its sting into the side of the hopper, beneath one of the wing lobes in the case of *Echthrodelphax*, and in various other positions in the case of other parasites, and the egg is deposited. The laying of the egg is again a very deliberate undertaking and the sting may remain inserted for a couple of minutes or more. Finally the sting is withdrawn, the front leg that grasps the hopper's neck is extended, the chelae or pincers fly open and the hopper is sometimes roughly jerked to a distance, sometimes more gently deposited on the plant. While grasping the hopper and inserting the sting, the parasite has been seen in some cases to freely use its mandibles on the neck in process of malaxation. After the operation, the victim usually appears weak and dazed, sometimes even lying inert on the ground, but sooner or later and sometimes very quickly, it recovers and starts feeding as if nothing had happened. Occasionally after capture, the prey is released without being stung, and it is probable that hoppers so released have already been stung by an earlier captor. Under unnatural conditions, such as in the confinement of a small jar or glass tube, and probably under pressure of hunger, the hoppers are frequently killed outright, and to come extent devoured. The position of insertion of the sting is apparently not always the same, this being sometimes inserted beneath the wing-lobe, and sometimes in the ventral side of the body, but the larval sac in either case appears beneath the wing-lobe. After the egg has been deposited, it is not for some time that the characteristic larval sac becomes evident externally. In the case of *Echthrodelphax*, I could distinguish the larval sac, having the appearance of a minute transparent vesicle, at the end of four days with the naked eye. In the case of a California species of *Haplogonatopus*, the period was not less than a week. On one occasion three cane leaf-hoppers were placed in a large glass jar with the *Haplogonatopus*, and two of them were seen to be quickly seized and stung. The next day the parasite was removed to another cage. At the end of six days, when the hoppers were examined, no sign of the larval parasite was noted, even with the aid of a weak lens, and it was supposed that they were unaffected. However on the ninth day, when they were again examined, the parasitic larvae were of considerable size, and obvious to the naked eye. The third hopper of the above produced no parasite and probably was not stung. As soon as the larval sac becomes visible, it is usually but a short time, a few days or a week before the larva becomes mature. The length of time no doubt varies somewhat according to the species, and according to climatic conditions.

The larva of the *Echthrodelphax fairchildii* while still attached to the hopper, appears as a small, nearly circular, impressed, black object, adherent to the young leaf-hopper. The latter seems hardly to be inconvenienced by the parasite, remaining as active and plump as the non-parasitized individuals. It is always the immature hopper that is attacked and a single hopper may sustain one or two parasites. They are generally fixed beneath the lobes, which develop into the tegmina or upper wings, one on each side of the body, if two be present; they are, however, sometimes found beneath the true wings.

After a time, however, (always shortly before the full growth of the parasite larva) the hopper becomes sluggish and then entirely stationary. This may happen either shortly before or not till some time after the black shell-like covering or larval sac of the parasite splits by a longitudinal (mediodorsal) fissure and exposes the back of the white maggot within. This torpidity of the leaf-hopper and the splitting of the covering of the parasite is the outward sign of a change of habits in the latter (being coincident with a moult and change of form of the parasite.) From this time until the hopper dies and the maggot finally quits hold of its prey the sight as examined under a lens forms one of the most repulsive sights that natural history can afford.

Soon after the splitting of the black covering and the exposure of the white maggot, a conspicuous change takes place in the color of the latter, it becoming pink or reddish. The maggot, which has hitherto fed delicately without doing any vital injury to its host, now proceeds to ingest the contents of the hopper in an indiscriminate manner, and the change in color is clearly due to this. If removed at this time from the hopper it is seen to have very mobile and hard (chitinized) mouth parts, while the thin and collapsed black covering still adheres some distance behind the head. Growth is extremely rapid and the simultaneous shrinking of the hopper, as its contents are absorbed by the parasite, enhances this effect. Thus when the splitting of the black covering takes place the hopper may be three or four times the size of the parasite, when the latter is full fed the proportions may be exactly reversed. The removal of the contents of the hopper can be easily seen through parts of the cuticle. Generally early in the proceedings the soft contents of one or both eyes and of the head are seen to be in rapid motion, like a boiling fluid; suddenly all the pigment is removed from one eye (usually the one on the opposite side to the parasite) and it becomes an opaque white spot, then the other is often similarly destroyed, or sometimes both more or less simultaneously.

Finally the maggot, when it has finished feeding, withdraws its head, and may then sometimes be seen busily engaged in applying sticky matter from its mouth to its body. Its surface is strongly adhesive and when it quits its prey, it is able (though of course quite legless) to crawl freely over any surface, however smooth. Soon it spins a neat white cocoon, from which it emerges as an active winged insect in about 18 days.

GENERAL HABITS OF DRYINIDAE.

In Australia, the small apterous forms of the *Gonatopus* type are essentially attached to the Jassidae and Fulgoridae, that feed on grasses and low herbage, and this was also the case with the many American species sent to Hawaii by Mr. Koebele. On the other hand, the Hawaiian apterous species are essentially arboreal, but it must be remembered that in Hawaii practically all the native Homoptera are attached to forest trees, the few that live on grasses being Jassids or Fulgorids almost certainly introduced, the Hawaiian fauna being altogether of a special nature. *Echthrodelphax* is also connected with grass-eating Fulgorids, or at least with those affecting low plants. The most minute species of *Neochelogynus* attack small graminivorous Jassids. The larval sac of these small robust insects is placed ventrally on the hopper behind the posterior legs, or on the side of the neck. Most of the species of this genus, however, attack tree Jassids, and the larval sac is attached behind the posterior coxae on the ventral surface of the body. Naturally all these insects are at times met with in the adult state by sweeping grasses, but not in any considerable numbers. The apterous insects of the *Gonatapus* group can be found in some numbers by special searching about the roots of grasses in Australia, especially on sandy banks, similar to those on which I used to take *Gonatapus* itself in some numbers twenty years ago in England. The tree-frequenting winged forms are only taken rarely and singly by beating branches of trees or shrubs, even in places where the dryinized hoppers are quite abundant, and where the mature insects can be obtained in numbers by breeding. *Paranteon* no doubt has special habits; for the sluggish hopper, that it affects, forms flocks of greater or less extent, and excreting much honey-dew, is invariably covered with swarms of ants, usually a moderate-sized species of the Formicidae. The *Paranteon* bears some slight resemblance to the ant in appearance, and this resemblance is enhanced by its actions. If a number of the parasites be bred together in a glass vial, they may be seen gathered in pairs, standing sub-erect on their four hind legs, face to face, stroking one another, licking each other's mouth, soliciting food. Now the ants, that attend the hoppers themselves behave in similar fashion, and it is most probable that they actually feed the *Paranteon*, which unless it were on friendly terms with the ants could never approach the hoppers to lay its eggs in these. It is only necssary to touch a twig on which a colony of the hoppers rest, to see how assiduous are the ants in protecting the colony from any interference. Further, it would be interesting to note what happens to the full-grown larva of the parasite, which must emerge from its sac amongst a swarm of carnivorous ants, that are always prepared to kill and carry off any weaker insect, that falls in their way. Most probably not only are the larvae not harmed by the ants, but they may be carried down by them to their underground nest, and pupate therein. In captivity the larva forms its cocoon well beneath the soil.

All the species of the Dryinidae, which have the front legs abnormally lengthened in the females, when resting, place these in a characteristic position. The knee-joints on either side rise high above the pronotum and often are brought together so as to form a complete angular arch over the thorax. In walking, the abnormally developed claw of the chelae is always folded back on the fifth joint of the tarsus, and is not used except specially for grasping its prey. In the comparatively slender, winged insects of the genera *Neodryinus*, *Paradryinus* and *Chlorodryinus*, the abdomen of the females is recurved or bent on its apical part, and is always kept in this position when the insects rest, and generally when hunting their prey; and this is also the case with the large apterous *Chalcogonatopus*. When at rest they have a most extraordinary appearance for they sit suberect on their tail (i. e. the recurved apex of the abdomen), supported otherwise by only the two hinder pair of legs, the front pair being held in the position already described, the tarsi usually somewhat inclined, and free from the surface on which the others rest. On the other hand, the slender, winged *Echthrodelphax*, and the small wingless insects of the *Gonatopus* group, whether resting or running, hold the body segements straight, and only in the act of stinging their prey are these bent or recurved.

The short-legged, stout insects with large stigma to the front wings naturally do not exhibit the peculiarities that are shown by the species of the above named genera. Many of them, moreover, seem to be better endowed with powers of flight, the sexual disparity is much less, the males are more hardy, and, in the case of *Paranteon* at least, copulation may take place many times, in striking contrast with the feeble male of *Echthrodelphax*, which frequently drops dead within a few minutes after the act.

Although in some cases a species of the Dryinidae will attack more than one species of leaf-hopper, and indeed sometimes parasitizes species of different genera, yet in the latter case these genera always belong to the same group of hoppers. In no case have we ever found one to attack a Jassid or Fulgorid indiscriminately. Indeed from a study of structure we should suppose such a case to be impossible. Riley however is said to have bred *Labeo typhlocybae* from a *Typhlocyba*, whereas this species of which the female was described as *Drynius ormenidis*, is well known to be a common parasite of the Fulgorid genus *Ormenis*, and it might be well to confirm Riley's unique instance. Also in need of confirmation is Lichtenstein's *Gonatopus ptinorum*, said to be parasite on the beetle *Ptinus fur*.

Like other parasitic Hymenoptera some of the Dryinidae are able to reproduce their kind parthenogenetically, and probably frequently do so in a state of nature. In one case that was noticed, that of a species of *Pseudogonatopus*, of the offspring thus produced only one in forty was of the male sex.

THE ECONOMIC VALUE OF DRYINIDAE.

The parasites of the group now under consideration have until lately been considered as more or less rare insects, and therefore it is of interest to consider the extent of their economic value. A fairly true estimate of this value can be made by carefully watching some common species of leaf-hopper, which is subject to their attacks, over a considerable period of time. It must be understood that the following remarks apply to species, which are found in countries where the winters are not cold enough to put a cessation to insect activity. If we keep watch on a species of hopper from the time when its numbers are at a minimum, it will usually be observed that the individuals become more and more numerous with each generation. At first the parasite is also very scarce, or for a time may not be observed at all, but it likewise increases in number with the increase of the hopper, so that both frequently attain their greatest abundance at the same time. In the case of a common Australian species of grass eating *Liburnia* and the *Pseudogonatopus* parasitic on it, which were observed for about three consecutive months, the visibly parasitized individuals, when the hoppers were most abundant, amounted to as high as 50 per cent of the whole. Many individual hoppers carried two to four, some even six parasites. Adults and all the earlier instars were attacked alike. This statement however, would give a very inaccurate idea of the true value of the parasite. Firstly, many of the apparently sound hoppers were affected by the parasite, which had not yet shown externally; secondly, an enormous proportion of them were in the young stages and incapable of breeding, and, for days or weeks to come, were liable to be parasitized before they could reach maturity. It will not therefore be surprising to learn that a few weeks after the parasites were at their maximum, the hoppers from their numerical maximum fell suddenly away to a minimum, being represented, in places where they had swarmed previously, by only scattered specimens.

It might have been expected that now the parasite would have been swarming in the locality, where so many dryinized hoppers had lately existed, the more so as, on account of their wingless condition, they would not be likely to stray far away from their birth place. This however was not the case, for just as the parasite reaches its maximum in numbers, at the same time as the hopper, so do the hyperparasites at the same time as the parasite. When the *Pseudogonatopus* was at its greatest numbers, the hyperparasites were noticed in the field in considerably greater numbers still. Of course it must also be remembered that in many cases the destruction done by the Dryinid parasite is supplemented by the work of other parasitic or predaceous insects. With the most successful hoppers (by which I mean those, which are most numerous in individuals), it would appear that at their numerical maximum, they exhibit signs of becoming a highly destructive pest, but just at this point (at any rate in normal seasons), they sudden ly, owing to the attacks of parasites or predators, fall away to about their numerical minimum.

To take another instance, a common species of *Siphanta* was observed in numbers in Northern Queensland in various localities, but not so numerously as a rule as to be considered injurious to any considerable extent. On the other hand, under unnatural conditions, it showed itself capable of doing the greatest damage, for an isolated colony established on a bush in the town of Cairns where its natural enemies had little chance of finding it, had so injured the bush that the owner cut away and destroyed a large portion of it. At Townsville, on an isolated row of trees, the same species had evidently increased to great numbers prior to our visit, as could be easily seen by the appearance of the affected trees, and the empty larval skins of the Siphanta. In this case, however, the parasites had already discovered their prey, and we saw few of the latter, but the cocoons, mostly empty, of a *Neodryinus* were so numerous, that as many as 32 were picked off a single fig-leaf! Egg parasites were also at work on the few patches of eggs that we found. Indeed in most cases, it will no doubt be found that the work of the Dryinidae, admirable as it is, to a greater or less extent is supplemented by that of other predaceous and parasitic insects. In fighting a leaf-hooper pest by the importation of parasites or predators, it will no doubt be generally found necessary to make a selection of carefully chosen enemies rather than to rely on a single specific enemy, though the latter might in some cases be perfectly successful, provided its hyperparasites be carefully excluded and that none likely to attack it already exist in the country to which it is imported.

How hardly the Dryinid parasites are at times pressed by their various hyperparasites, we often observed. To cite one instance, from about fifty cocoons of several species of parasites, obtained from grass-eating Liburniae at Redlynch near Cairns, one solitary male *Echthrodelphax* alone emerged, all the rest being hyperparasitized, and similar observations were made in several localities.

In estimating the value of the *Dryinidae* we should note the fact that, so far as is known, a dryinized leaf-hopper may be counted as a dead hopper. In no case is it probable that it would be capable or reproduction after being stung by the parasite and usually it dies at the moment of emergence of the larva of the latter. In one instance a very large nymph of a *Siphanta*, bearing a larva of a *Paradryinus*, after the latter left it, had sufficient strength to moult, and produced a crippled nature insect, which quickly died; but this case was quite unique. Nymphs of leaf-hoppers bearing a parasite never attempt to moult. On the other hand, where a Dryinid attacks mature leaf-hoppers, these may of course have already deposited their eggs, but such cases are probably few.

MATURE LARVAE OF DRYINIDAE.

On leaving the host, the full-grown larva is of elongate-ovate form, pointed anteriorly when extended, the anterior segments being much narrower than the posterior, the head more or less retractile and like the mouth parts, usually very mobile. The cuticle is microscopically rugulose or corrugated, siometimes quite bare as in some *Neodryinus* and *Paradryinus*, but in *Pseudogonatopus* (at least in some species), there are several longitudinal rows of very short and widely separated bristles and a row of latero-subventral ones on each side are more developed, placed on tubercles more developed than the others. In *Neochelogynus destructor* the segments are circularly ridged and the ridges set with minute tubercles placed close together, each tubercle bearing a longish hair.

The chitinization of the head varies in different genera or species, but conspicuous always are the large mandibles. In some *Neodryinus* and *Paradryinus* these appear to have an oblique cutting edge, which is crenulate or denticulate. In *Neochelogynus* they appear to be simple and simply pointed at the apex, and at rest the tips pass one another. The upper lip or labrum is very broadly rounded or truncate at the apex and there ciliated, and often the mandibles are largely concealed beneath it. The lower lip apically is usually strongly bent upwards at an angle with the lower surface of the head. The mouth opening is large and only partially closed by the large mandibles and the maxillae, which lie beneath them. There is a single jointed (faint indications of a secondary division may sometimes be noticed) maxillary palp, bearing a few microscopical hairs at it apex, or sometimes one more conspicuous spinose hair and some shorter ones. The head is sparingly set with hairs or bristles which differ with the species, and these distinctions possibly yield characters of generic importance.

All the larvae known are very active and most of them crawl about quickly on their emergence from the sac, in search of a proper place for spinning their cocoons. Some however like *Neodryinus* pupate on, or close to, the spot at which they issue from the host. They show many differences in colour, according to the species, the majority being white or pinkish. Some however are brown and others light green. It is note-worthy that a light green larva may issue from the sac on a brown coloured Jassid while another species from a light green Jassid may not be green at all. These colour distinctions are I believe, constant for a species.

COCOONS OF DRYINIDAE.

The larvae of all the known species spin a compact silken cocoon, which often consists of two parts, an inner adapted to the form of the larva and an outer and wider covering. The species of *Neodryinus* further elaborate this by fixing over it a roof, formed of the greater part of the larval sac. Many of the cocoons are highly charateristic of the genus or species, and though in some the details of shape, etc., are not absolutely constant, yet in many cases the species can be immediately distinguished by an examination of the cocoons, provided that these are formed on similar substances. When found on very different surfaces there may naturally be considerable difference exhibited by cocoons even of one species. The cocoon of *Paradryinus* is elongate and cylindrical and often found on the surface of green leaves. Under these conditions the cocoon of *P. threnodes* is densely studded with round patches of epidermis-stripped off from the leaf surface; that of *P. koebelei* is less densely covered, with more elongated fragments; while *P. venator* also uses roundish fragments, but the cocoon is more carinated.

The cocoon of *Chlorodryinus* is long, narrow and cylindrical and no fragments of leaf substance are woven into the surface. That of *Neodryinus* is ovate and the upptr and lower walls of the marginal part are strengthened with great numbers of vertical pillars. In addition as above mentioned, the larger part of the ruptured larval sac is removed from the hopper and attached as a roof over the cocoon. This sac being of the usual circular form, when ruptured by the escaping larva, gapes open like a bivalve shell, as do those of all other Dryinidae known to us. These two valves are stretched wide open over its cocoon by the mature Neodryinus larva, and so fastened, the whole forming a subovate or subreniform roof over just so much of the whole cocoon as covers the insect within. Of what use to the genus this extra shelter may be we cannot conjecture. It certainly does not make the cocoon less conspicuous, as do the fragments from the surface on which it pupates that of *Paradryinus*, not yet does it keep out the spores of fungi to which both genera and some others are very liable. All the known hyperparasites attack the larva before the cocoon is made and not afterwards, so they do not enter into the question.

The cocoons of the short-legged genera, with large ovate stigma to the front wings are almost certainly under natural conditions subterranean. They are of shorter, wider form than those of the more highly evoluted group of genera; in fact, often nearly round, and are covered with particles of the soil or debris amongst which they are formed, so as to be most difficult to detect by sight.

### LARVAL SAC OF DRYINIDAE.

The larval sac of the Dryinidae is of circular form, the sides being more or less compressed according to the species. The colour is frequently uniform, but in some species it is more or less, or even conspicuously, variegated. Towards the point of attachment the surface is often nearly smooth and sometimes shining, but externally more or less rugulosely sculptured. This sculpture is sometimes so well-marked and the pattern so regular, that under a strong lens the surface of the sac presents a really beautiful appearance. In some species the external rugulose portion bears short, stiff, erect, bristles. The larval sac is formed of the skin of the curled up larva together with one or more of the adherent skins of its earlier ecdyses. After a careful examinations of the sacs of a large number of species, it would appear that the full number of larval moults is four (or possibly even five) but in some species the number may be reduced. At least in the case of a species of *Neodryinus* that was most closely investigated the number of ecdyses cannot be less than four (including that from larval to pupal condition) as is evident from an examination of the sac. In this genus the sac is partially removed to form a cover for the cocoon when the larva leaves its host. This cover is subovate or reniform and consists of two distinct larval skins attached to one another, longitudinally fissured at the moults and spread out valve-like, the smaller surrounded by the larger. Each of these skins is pierced by nine spiracles of which one (at the one end of the series) is indistinct in the larger skin. Besides these, one still smaller skin is left beneath the wing-lobe of the host and this is also distinctly pierced by a series of spiracles. It is possible that there is yet another smaller skin more internally placed, though this was not observed. Therefore there are at least four and possibly five moults in this species.

### POSITION OF THE LARVAL SAC.

In dryinized Homoptera there is great diversity in the position of the larval sac. The position may vary in the case of a single species, or in different species of a genus, or it may be absolutely constant, and not only in a species, but apparently in all the species of a genus.

In most of the species of *Neochelogynus* the larval sac is ventral, and lies immediately behind the posterior coxa; in *N.*

*coriaceus*, however, it is placed at the side of the neck. In *Paranteon* the larval sac is placed either dorsally or ventrally on any abdominal segments, as many as six or eight on a single individual; more rarely it has been found beneath the thorax, at the insertion of the hind coxae or on the prothorax laterally or beneath. In *Pseudogonatopus* the sac is always dorsal or dorsolateral on the abdomen and several sacs may be found on one Delphacid. In *P. stenocrani* on the nymph of *Stenocranus dorsalis* the sac stands up erect like a wheel in the middle line between the wing-pads, giving it a most extraordinary appearance. All the species of *Echthrodelphax, Paradryinus, Thaumatodryinus* and *Neodryinus* have the larval sac placed beneath one or other wing lobe without variation. In *Eukoebelcia*, the sacs are abdominal, variously placed, often several on one host. .

ABNORMAL LENGTH OF TIME SPENT IN THE COCOONS

Considering the whole number of species of Dryinidae known to us the average length of time spent from the period of spinning the cocoon to the emergence of the mature insect, would be from two to five weeks. Consequently as the egg state and the larval stages are known to be of short duration, many generations can be produced in a year. There comes a time however when, owing to the absence of the host in a suitable stage of development for the parasite that attacks it, or for other reasons, the Dryinid itself has to assume a lengthy resting period. So far as our observations go, this resting stage in the case of the parasite always takes place when the larva has spun its cocoon and before pupation. No doubt in countries with cold winters many pass the winter months in this stage; and in warm countries this quiescent condition is liable to be assumed at any season. During the summer months in Hawaii, occasional larvae of *Echthrodelphax* assume this torpidity in the cocoon, remaining in this condition for months, though perfectly healthy; and in some of the winter months the number that remain as larvae, when others (collect ed at the same time and treated in the same manner) emerge after the usual period, may amount to not less than 25 per cent. There is reason to suppose that not only a lowering of temperature, but that dryness even with increased temperature, may in some cases cause this torpidity. About 2,000 cocoons of Dryinus, sent to Hawaii from North America by Mr. Koebele, in the early part of November, produced in Honolulu two males a few weeks after arrival, and one male a month after these. The rest remained as torpid and shrunken larvae in the cocoon for five months after they had been collected.

They were then taken to a cooler and damper locality, and all that were not killed by hyperparasites produced mature insects of both sexes in a short time. A number of curious cases were noticed in Queensland. For example, a larva of a *Paradryinus* that spun up on Oct. 1st, was still in the larval state, and, as evidenced by occasional movement, alive on Dec. 12th, though much shrunken. It was then killed and preserved. Larvae of this same *Paradryinus* that formed their cocoons in numbers on Nov. 22nd, had all emerged as perfect insects before Dec. 12th. The cause of the retardation in development is not clear in this case, but that it may under certain conditions be of an advantage to the species is evident. This would especially be the case in a country subject to long droughts, when vegetation of many kinds is dried up for long periods together, during which the hosts of these parasites must almost cease to exist in a proper stage of development for their attack. It may also be of use against the attack of hyperparasites, if, as it appears, these have not the same habit of lying dormant, except of course during winter in cold countries. * * * * * * * *

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## *DETERMINATION OF SUCROSE IN PRESENCE OF LAEVULOSE AND DEXTROSE.*

The March number of the Bulletin of the French Sugar Chemists Association contains H. & L. Pellet's reply to an article of Remy's covering the same subject and which appeared in the same journal.

Leaving out the controversial part, the salient points of the interesting paper are the following:

As the result of long studies made of the influence of subacetate of lead on reducing bodies the authors have substituted for the subacetate the normal acetate neutralized with acetic acid. Sulphurous acid is used for decolorizing the molasses. This acid added in very large quantities and in the highest concentration obtainable did not affect the sucrose. The solution to be polarized before inversion would therefore be strongly acid.

For some time it has been the authors' contention, that all liquids should be rendered acid before polarization even in the case of a simple polarization of a liquid free from reducing sugars. As acid they use acetic acid.

In their first method they polarize before inversion all liquids previously made strongly acid with sulphurous acid; but later, after Zamaron published his method for decolorizing canemolasses by means of Hypochlorite of Lime or Soda, they adopted it because it allows of the polarization of very dark products and that without the use of subacetate. They satisfied themselves, that the results thus obtained were exactly the same as those obtained by the first mentioned method, being at the same time much less complicated.

The authors also made comparisons between the sucrose found by Clerget's and the authors' modification of Violette's method. The results agreed closely, as did also those of a series of similar comparisons made by Tervooren (Archief voor de Java Suikerindustrie 1904).

The authors conclude, that Clerget's principle applied to the determination of sucrose yield results of sufficient accuracy if all the necessary precautions are taken. Clerget's formula should be determined for each place and each instrument.

H.

## *METHODS FOR THE CALCULATION OF EXTRACTION.*

ADOPTED BY THE

HAWAIIAN SUGAR CHEMISTS' ASSOCIATION
NOVEMBER, 1904.

Amended June, 1905.

As but few changes were made at the general meeting of the Association in 1904, in the methods agreed on in 1903, it was not deemed necessary to issue a new edition.

Correspondence received during this present season shows that the methods chosen were interpreted in many different ways, the main difference being in the interpretation of the term, "cane."

Throughout the calculations given below, as well as those given in the methods of 1903, "cane" must be understood to mean the raw material in the condition in which it enters the mill.

### BASIS OF CALCULATION.

The amount of sucrose coming to the mill in the cane is to be used as the basis of calculation; and this amount is found from the weight of the cane and the per cent. sucrose in the cane calculated by the following formula:

$$\frac{\text{Sucrose \% Normal Juice (100—Fiber \% Cane)}}{100}$$

### NORMAL JUICE.

Normal juice is the actual cane juice, and its composition is to be found as follows:

Density.—The density of the normal juice is found by averaging the density of the juices from the different sets of rollers when no water is used for maceration. Such a test should be made once a week, and the factor

$$\frac{\text{Brix Mixed Juice} \times 100}{\text{Brix 1st Mill Juice}}$$

used for daily calculations.

Under "first mill juice" is to be understood the average of the juices expressed before the bagasse enters the second mill.

Purity.—The purity of the normal juice is found by averaging the purity of the mixed juice with that of the residual juice in the bagasse:

$$\frac{\text{Extr.} \times \text{Purity Mixed Juice} + (100 - \text{Extr.})\ \text{Purity Residual Juice}}{100}$$

The purity of the residual juice should be determined in one sample of bagasse each day.

Sucrose: $\dfrac{\text{Brix Normal Juice} \times \text{Purity Normal Juice}}{100}$

### CANE.

Fiber.—Wherever the term fiber appears, it stands for the total insoluble solids.

In determining the fiber in the cane, the amount of field trash weighed with the cane should be determined once a day on one average car; the amount of fiber determined, and this aded pro rata, to the amount of fiber found in the sample of clean cane.

Sucrose: The Sucrose % cane is found according to the formula:

$$\frac{\text{Sucrose \% Normal Juice } (100 - \text{Fiber \% Cane})}{100}$$

### BAGASSE.

Sucrose: determined by aqueous diffusion

$$\text{Soluble Solids: } \frac{\text{Sucrose \% Bagasse} \times 100}{\text{Purity of Residual Juice}}$$

Moisture: found by drying to constant weight at 100° C.
Fiber: found indirectly according to the formula:

$$100-(\text{Moisture} + \text{Soluble Solids})$$

### EXTRACTION.

The term Extraction is used to indicate that percentage of the sucrose in the cane, which is obtained in the mixed juice, expressed by the formula:

$$\frac{\text{Sucrose \% Mixed Juice} \times \text{lbs. Mixed Juice}}{\text{Sucrose \% Cane} \times \text{lbs. Cane.}}$$

Where accurate weights are not available the extraction may be calculated according to the following formulae:

$$\text{Bagasse \% Cane} = \frac{\text{Fiber \% Cane} \times 100}{\text{Fiber \% Bagasse}}$$

$$\text{Sucr. in Bag. \% Cane} = \frac{\text{Bagasse \% Cane} \times \text{Sucr. \% Bagasse}}{100}$$

$$\text{Extraction \% Cane} = \text{Sucr. \% Cane} - \text{Sucr. in Bagasse \% Cane}$$

$$\text{Extraction \% Sucr. in Cane} = \frac{\text{Extraction \% Cane} \times 100}{\text{Sucr. \% Cane}}$$

### EXAMPLE.

Available data:—

| | | |
|---|---|---|
| 1st Mill juice | = Brix | 20.00 |
| Mixed juice | = Brix | 17.00 |
| | Sucrose % | 15.30 |
| | Purity | 90.0 |

| | | | |
|---|---|---|---|
| Residual juice | = | Purity | 75 |
| Extraction | = | Approximately | 93 |
| Cane | = | Fiber % | 12.5 |
| Bagasse | = | Sucrose % | 4.30 |
| | | Moisture % | 45.0 |

$$\text{Coefficient} = \frac{\text{Brix Mixed Juice}}{\text{Brix 1st Mill Juice}} \quad \ldots\ldots\ldots\ldots 99.0$$

Normal Juice:

$$\text{Brix} = \frac{20.00 \times 99.0}{100} = \quad 19.80$$

$$\text{Purity} = \frac{(93 \times 90) + (7 \times 75)}{100} = \quad 88.95$$

$$\text{Sucrose \%} = \frac{19.80 \times 88.95}{100} = \quad 17.61$$

$$\text{Cane: Sucrose \%} = \frac{17.61 \times (100-12.5)}{100} = \quad 15.41$$

Bagasse:

$$\text{Soluble Solids \%} = \frac{4.30 \times 100}{75} - \quad 5.73$$

$$\text{Fiber \%} = 100 - (45.0 + 5.73) = \quad 49.27$$

$$\text{\% Cane} = \frac{12.5 \times 100}{49.27} = \quad 25.37$$

$$\text{Sucrose in Bagasse \% Cane} = \frac{25.37 \times 4.30}{100} = \quad 1.09$$

$$\text{Extraction \% Cane: } 15.41 - 1.09 = \quad 14.32$$

$$\text{Extraction \% Sucrose in Cane} = \frac{14.32 \times 100}{15.41} = \quad 92.03$$

ERNEST E. HARTMANN, President.

EDMUND C. SHOREY, Sec.-Treas.

Honolulu, June 19, 1905.

# *REVIEW OF THE INSECT PESTS AFFECTING THE SUGAR-CANE.*

By H. A. Ballou, B. Sc.,

Entomologist on the Staff of the Imperial Department of Agriculture.

At the previous Conferences there have been presented papers on this subject, which, together with such other information as has come to hand from time to time, have appeared in the publications of the Imperial Department of Agriculture. This paper is intended to furnish a concise summary of what has been published, together with an account of a borer in canes (*Castnia licus*) which has recently appeared in British Guiana.

## THE MOTH BORER.

### (*Diatraca saccharalis.*)

*Life-history.*—The egg is laid on the leaf; the larva lives about ten days in the outer leaf-sheath and then bores into the heart of the plant which, later, withers and dies. These withered shoots are known as dead hearts and are an indication of the presence of the larvae in a stool of canes. The larvae in a shoot may become well developed before the shoot withers; they also penetrate the stem of the cane, and may go from on shoot to another in the same stool. The larval life lasts from thirty to thirty-five days.

The pupa is formed in the tunnel made by the larva, near the surface of the cane, protected by a slight web across the mouth of the tunnel. The pupal period lasts about six days. The imago has a short existence, living but a few days. It is not a strong flyer, and remains inactive by day, flying at night. The female lays from 100 to 300 eggs.

*Description.*—The egg is flattened, oval, slightly convex, upper surface finely reticulate. The eggs are laid in clusters averaging about nineteen to a cluster, the range being from four to fifty-seven, usually between ten and thirty. When first laid they are light-yellow, becoming orange-brown later, and just before hatching the centres become very dark. The egg is about 1 mm. (1-25 inch) in length.

The larva is about 2 mm. (1-12 inch) in length when first hatched, of a light-orange color, with numerous short, black hairs. The mature larva is about 1⅛ inches in length, the head is dark-brown or black, with a V-shaped mark lighter than the rest of the head. The pronotum is dark-brown or black. The remainder of the body whitish with stigmata black, and with a few dark hairs scattered over the body. The head and pronotum are hard, the remainder of the body being soft.

The pupa is naked, shiny brown, ½ to ¾ inch in length, with short spines and callosities on abdominal segments.

The imago or moth is of a dull straw color on upper surface of fore wings, with a few dark spots; the hind wings are whitish, under surface of wings uniformly light, the body brownish. The expanse of wings is 1⅛ to 1⅝ inches, length of body ⅝ to ¾ inch.

*Parasites.*—The eggs are attacked by a small hymenopterous parasite (*Trichogramma pretiosa*), and the larvae are sometimes attacked by a fungus (*Cordyceps barberi*).

*Injury to Canes.*—The moth borer injures the cane in several ways: by killing the young shoots; by eating out the sugar-containing portion of the stem; and by affording easy access to fungoid diseases, especially the rind disease (*Trichosphoeria sacchari*).

*Prevention.*—Canes that show borer holes should not be planted, nor should such canes be sent from one estate or from one colony to another.

*Remedies.*—Cutting out the dead hearts seems to be the most generally practiced of all remedial measures. These should be cut as low as possible to ensure getting below the larvae. The dead hearts are burned or fed to stock, and the larvae are thus destroyed. The collecting of eggs has been practiced but does not seem to be generally carried out in the West Indies. Care should be taken to distinguish those eggs containing parasites: parasitized eggs should not be burned with the others, but should be kept to give the parasites an opportunity of emerging.

### HARD BACK.
### (*Ligyrus tumulosus.*)

This is the common black hard back, the larva of which is a white grub living in the ground feeding on vegetable matter. There seems to be no evidence that this is a serious pest to sugar-cane, but a closely related species, *Ligyrus rugiceps*, is a pest of canes in Louisiana, and the West Indian form may do more harm than has been realized.

### THE WEEVIL BORER.
### (*Sphenophorus sericeus.*)

*Life-history.*—The eggs are laid singly, embedded in the cane to a depth of ⅙ inch. The egg hatches in four days, and the larva or grub eats its way into the cane, forming a small tunnel which increases in size as the larva grows larger. The larval period or grub stage lasts about seven weeks. During this period the larva destroys most of the interior of a joint of cane. The pupa is formed in the tunnel made by the larva and is covered with a large, rough cocoon made of the fibres of the cane. The pupal period lasts about ten days, and at the end of that time the adult beetle emerges from one end of the cocoon. The beetle is active, flying about at night. The female, after mating, begins egg-laying which continues for some time. The beetles may be kept alive several weeks.

*Description.*—The egg is oval, about 1-15 inch in length, and is nearly transparent.

The larva is a small, white grub when first hatched. It has no legs but has a hump near the hind end of the body by means of which it pushes itself along the tunnel. When full-grown the larva is about $\frac{1}{2}$-$\frac{5}{8}$ inch in length and $\frac{3}{8}$ inch in thickness at the swollen part of the hind body.

The pupa is soft, whitish, enclosed in a rough cocoon of coarse fibres in the rotten cane where the larva has lived.

The adult beetle is reddish-brown with black markings. There are three longitudinal black marks on the thorax, and the wing covers are edged with black, and on each wing cover there is a black line and black spot. The front of the head is produced to form a stout beak or snout. The length is about $\frac{1}{2}$ inch, the width about 3-16 inch.

*Injury to Canes.*—The damage caused by this insect consists in the destruction of canes growing in the field, injury to young canes springing from cane plants, and possible injury to young canes springing from cane stumps.

*Remedies and Prevention.*—Destroy all infested canes, cover cut ends of cane plants, cane tops, and ratoon stumps with mould as soon as possible, or plant so that no ends shall be left exposed above ground, and destroy all stumps not intended for ratooning as soon as possible after canes are cut. Tarring the ends of cane plants, as recommended for preventing fungoid attack, would probably be useful.

### THE ROOT BORER.
### (*Diaprepes abbreviatus.*)

*Life-history.*—Eggs are laid in clusters ranging in number from eight to 130 on upper side of leaf, not necessarily that of a food plant. When first laid, the eggs are white; later they become tinged with yellowish-brown. The eggs hatch in ten days. The newly hatched larva is about 1-18 inch in length, pale yellowish-brown in color. There are no legs, and the body is not swollen to form a hump like that seen in the larva of the weevil borer. The larvae or grubs fall to the ground and burrow beneath the surface. They begin feeding almost immediately on the roots of plants. They attack the canes first at the soft ends of the adventitious roots, the root stock being attacked later. The larva enters the cane about 9 to 11 inches below the surface of the ground, works its way upward several inches, then turns and descends and enters another cane. "One grub is often responsible for the death of a whole stool of canes."

The larval period extends over 300 to 312 days, and the mature larva measures ⅞ to 1 inch in length, and 5-16 to ⅜ inch in diameter.

The pupa is formed in the ground where it is enclosed in an earthen cell, 6 or 8 inches below the surface or in the cane, in which case it is enclosed in a cocoon similar to, but rougher than, that of the weevil borer, or in a nest of decaying leaves. The pupal period is about fifteen days.

The imago or adult beetle is at first soft and brownish-white. In two or three days it becomes hard and assumes its characteristic colors. The thorax is brownish with fine white pubescence, which gives a spotted appearance, wing covers greenish white with longitudinal brownish or bronze stripes; head brownish with stout snout or beak, the legs brownish, femora somewhat swollen.

The length of life of the adult is about twenty days, during which time mating and egg-laying occur. The female lays about 240 to 270 eggs.

*Food Plants.*—This insect is probably a very general feeder. It is known to feed on sugar-cane, sweet potato, guinea corn, imphee, and ground nut, and has been found eating the roots of cacao trees in St. Lucia. (See Agricultural News, Vol. III, p. 264.)

*Remedies.*—Sweet potatoes and imphee should not follow canes in field culture, nor should these be followed by canes. A crop not attacked by the root borer would be advisable, or no crop, with the removal of the cane stumps. The larvae of the root borer can live only about fifteen days without food, and to deprive them of food will be greatly to reduce their numbers. The following plants do not seem to be attacked by the root borer: ochro, cassava, yams, and eddoes, woolly pyrol, pigeon peas bonavist, rounceival pea, bean.

### THE CANE FLY.

(*Delphax saccharivora.*)

This small insect, although at one time believed to be a very severe pest, is not now considered as such, though generally present in small numbers each year. It appears to be well controlled by the lady-bird beetles (*Coccinellidae*) and the lace wing (*Chrysopa* sp.) except for occasional outbreaks on small areas. The presence of *Delphax* is generally indicated by black blight.

### SCALE INSECTS.

Three species of scale insects are known to attack canes in the West Indies, viz., *Dactylopius sacchari, Dactylopius calceolariae*, and *Aspidiotus sacchari.*

These species of *Dactylopius* are "mealy bugs," soft-bodied insects covered with mealy wax. They attack the stems and are protected by the leaf-sheaths. *Aspidiotus sacchari* is a small, rounded, straw-colored scale insect. These insects do but little harm, probably, and in the time ordinarily required for the growth of the crop would not become very numerous. No treatment is practicable except the exercise of great care not to plant infested canes.

### THE SHOT BORER.
(*Xyleborus perforans.*)

This is a small, brownish beetle about 1-10 inch in length. The greatest injury to canes from the boring of this insect is that the holes in the hard rind of the cane furnish an easy entrance for fungoid diseases such as the rind disease. As the species of *Xyleborus* readily attack dead and dying plants and multiply in them rapidly, the prompt destruction of dead and dying canes will have the effect of reducing the number of shot borer and checking its development and spread. The shot borer has not been prevalent in the West Indies for the past two years.

### THE LARGER MOTH BORER.
(*Castnia licus*, Drury.)

This insect was first reported to the Imperial Department of Agriculture in October, 1904 from plantation Enmore, British Guiana, where it was then causing serious injury to the canes.

Mr. Bethune, manager at Enmore, sent specimens of the larval and adult forms of the insect as well as pieces of cane and a stool of cane stumps showing the damage done, accompanied by statements as to its destructiveness. The Executive Secretary of the British Guiana Board of Agriculture forwarded a report by Mr. Ward, Agricultural Instructor, and further specimens accompanied this report.

From such correspondence and reports, and the specimens and material received, this paper has been prepared, the writer having had no opportunity of studying the insect in the field.

The egg is about 4 mm. ($\frac{1}{6}$ inch) in length and 1 mm. (1-25 inch) in width, spindle shaped, tapering to a point at either end, with five prominent longitudinal ribs from end to end. The color ranges from a light-gray (nearly white) to a darkgray. Eggs laid in captivity hatch in three or four days. Eggs have not been found in the field, and it is not known where they are laid. In captivity the eggs are laid singly and unattached.

The newly hatched larva (in captivity) is large in comparison with the size of the egg. Full-grown larvae are about 2½ inches long and ½ inch in diameter. The head is large, reddish-brown in color, with large powerful mandibles, with which it eats its way through the canes. The mandibles are shiny-black. The segments of the thorax are the largest, thus giving the body its greatest size just behind the head. The abdominal segments are nearly uniform in size decreasing gradually posteriorly, the last one being the smallest.

The thoracic legs are small, brownish, situated on the large fleshy swellings of the three segments of the thorax. The abdominal legs are soft protuberances on the third, fourth, fifth, sixth, and last abdominal segments. All the body segments are swollen and prominent. The color of the larva is whitish; the spiracles are very prominent, being large, and brown in color. There are a few pale hairs most plainly seen on the head, on the last abdominal segment, and on each segment below the line of the spiracles. The skin is shiny and slightly transparent.

On the dorsal surface of each of the second and third thoracic and the first seven abdominal segments, there is a small area set with short, brown spines or callosities, which serve to assist the larva in travelling along the tunnel in the cane.

The pupa is formed either in the canes at the base of the stool or in the ground near the canes. The pupa is brown in color about 1½ inches in length. The wing pads, antennae, and proboscis are very plainly visible. On the dorsal area of each of the abdominal segments, except the last, are spines and thickened processes. On the first six segments there are two rows and on the seventh and eighth there is one row across the segment. These spines are short, sharp and directed backward, and assist the pupa in wriggling its way either through the tunnel in the cane toward the top of the stump or through the ground toward the surface when the adult or imago is about to emerge. The pupa is sometimes enclosed in a rough cocoon formed of the fibres of the cane and sometimes in an earthern cell. (I have not seen a cocoon and only one pupa—that one, an imperfect one.)

The imago has a spread of wings of 3 to 3¼ inches. The body is 1¼ to 1⅜ inches long. The color is dark, brownish-gray, lighter beneath.

The fore wing is crossed on the upper surface by a broad white band just within the middle: outside this and nearly parallel with it a short white band extends from the front margin about half-way across. These white bands are seen on the under side of the fore wing also. Along the outer margin is a row of small, light spots which are not conspicuous.

The hind wing has a white band on the upper surface running across it near the middle. This is interrupted, near the front margin, making two distinct spots, behind which the band gradually increases in width until near the hind margin, where it is at its widest. A corresponding white band is seen on the under surface of the hind wing, but it is narrower, and the two spots near its beginning are less distinctly separated. Along the outer margin of the hind wing above are six spots of pale orange, the first three smaller and less distinct than the last three.

The head is large, with large, prominent eyes of a dark, velvety-brown color. The antennae are slender, swollen toward the end, tipped with a small, slightly curved point, dark-brown in color, lighter at the tip. The proboscis is slender, light-brown in color, about ½ inch in length, coiled under the head when not extended for feeding, etc.

The body is robust, clothed with coarse scales which are long and hair-like at the anal end. Color, similar to the wings, dark-brown above, paler below.

*Habits.*—The eggs are laid (in captivity) singly and not attached. It is not known where they are deposited in the field, but it is suggested that they may be laid in the axils of the leaves, or in the ground at the base of the plant.

The larva enters the cane at the base of the plant and tunnels upwards about 2 feet and then turns and goes back through the same tunnel and bores its way into the underground part of the plant. Canes have been found in which the larvae evidently entered high up on the plant and worked their way downward, but such exceptions are rare.

It is not known how long a time is required for the growth of the larva from the hatching of the egg to the forming of the pupa. Only one larva has been found in a cane, and it is likely that one larva attacks more than one cane, perhaps all the canes in a stool, as in some cases the underground stems are all tunnelled through, so that all the tunnels in the stems of a stool are connected. In some cases, too, the underground stems are eaten through at the sides, so that the tunnels connect with the soil around the plant. It is not known whether the larva tunnels underground from one stool of canes to another, but it seems likely. Larvae in captivity in the laboratory of the Imperial Department of Agriculture tunnelled through and through the soil in a glass dish in which they were kept. The soil was 6 inches deep and the larvae went to the bottom of the dish, and the tunnels penetrated in all directions through the soil.

The duration of the pupal stage is not known, nor is it known whether the adult feeds at all after emerging from the pupa. The adult or imago is a day-flying moth, greatly resembling a butterfly in its general appearance.

The damage to the canes is of two kinds. The larva eats out a large amount of the sugar-containing portion of the cane, and so thoroughly tunnels the stumps and underground portions that it is impossible to get ratoons from them.

*Occurrence.*—The larger moth borer has been known at plantation Enmore for the past three years, but has not occurred in seriously large numbers until the present season (1904). The moths have been most abundant in January and February in previous years, and a few have been seen in May or June, following a mid-year cutting of canes.

As the specimens received from British Guiana appeared to be identical with some large caterpillars received some years ago from Marienburg estate in Surinam, a letter of inquiry was sent to Dr. C. J. van Hall, Director of Agriculture for the Dutch West Indies, asking for particulars as to the outbreak in Surinam. Dr. van Hall wrote that the description of the pest corresponded with a pest of canes known at Marienburg some five or six years previously. "The pest appeared suddenly and assumed a dangerous character, but very soon the borers disappeared and so far as we know, they have not been seen here any more." Early in 1903 a large lepidopterous insect was sent to the Head Office from Trinidad, which was said to be a borer in bananas. The specimen was very badly injured and was not identified, but it is believed to be the same as the one under discussion.

*Remedies.*—Several remedies have been suggested, but only two have been tried. These are (1) catching the adult, while flying, with nets, and (2) plugging the borer holes in the top of the cane stumps with clay to prevent the emergence of the adult. By the first of these methods large numbers of the moths were caught by coolie children at plantation Enmore. The second seems not to be very efficient, as the clay crumbles in the sun and opportunity is thus provided for the escape of the moths. Carbon bisulphide is not available in British Guiana, or it might be possible to make use of this valuable insecticide. The moths have not been observed to feed on any flowers, nor will they feed on sweets provided them in captivity. If they were attracted to any food, use might be made of poisoned baits.

## *BACTERIA FOR FERTILIZER.*

### A Method of Utilizing Microscopic Organisms for Increasing the Quantity of Nitrogen in the Soil.

A great deal of interest was aroused a short time ago by the announcement that Dr. George T. Moore, of the Department of Agriculture, has succeeded in developing a form of culture in which nitrogen-producing bacteria could be readily transported in such a way as to make them available for use in stimulating the growth of certain legumes.

A few years ago the discovery was made that the nodules found on the roots of certain legumes were in reality collections of bacteria which were engaged in converting nitrogen, drawn from the atmosphere, through the plants from an insoluble to a soluble form. Since that time, a number of scientists have been engaged in developing some system by which the growth of these nodules could be stimulated so that these organisms would accomplish a large amount of work now possible only by the use of chemical salts containing soluble nitrogen. Professor Nobbe, a German, demonstrated that by putting some of these nodules into the soil, he could artificially inoculate and thus develop tubercles on legumes where it was impossible to grow them without inoculation. Professor Nobbe, however, was not able to develop a satisfactory culture for these organisms, and his experiments were therefore only partially sucessful.

The main feature of Dr. Moore's discovery consists in the development of the idea that bacteria grown upon nitrogen-free media will retain their activity for a long time if carefully dried out and then revived in a liquid medium later. Dr. Moore discovered that by dipping bits of cotton in the culture which he had developed, he could secure large colonies of bacteria which could be easily transported over very long distances.

A patent was secured of the process in March, 1904, but was deeded in trust to the Department of Agriculture for American Farmers. The Department of Agriculture has since that time been supplying colonies of these bacteria, free of charge, to the limited number of American farmers whom its facilities make it possible for it to serve. At the same time, the Department has given certain reputable private companies every opportunity to learn the method of producing these bacteria and these companies are now serving the general public.

The culture, in the form in which it is sent out, consists of small packages of dried cotton wrapped in tinfoil and numbered. These packages are accompanied by complete directions and, if purchased from a reputable house and utilized according to the directions, ought to produce favorable results.

As a result of the marvelous stories which have been told concerning this product, misconceptions have arisen concerning the scope of the work of which the bacteria are capable and the character of the crops to which it can be applied. The Department of Agriculture has attempted to keep a record of the results obtained of the cultures which it sends out. Up to the middle of November last the Department had received reports from about 2,500 experiments and of these about 1,300 reported a definite increase in crop, 575 reported failure owing to bad season, poor seed and various other causes, and about 300 reported that there was no appreciable increase in the crop owing to the fact that organisms were already present in the soil. The total percentage of failures out of all reports received was 26.

The experiments, up to the present time, indicate that the bacteria have no material effect on any except leguminous plants and, furthermore, that the culture must be prepared for each individual species of legumes, that is to say, the culture which will produce nodules on alfalfa will not necessarily have full effect on soy beans, and the culture prepared for soy beans must be varied somewhat to make it successful with cow peas or red clover or any other form of legume.

Results obtained by the use of the bacteria under favorable circumstances have been truly remarkable and there is every indication that, when the culture is good and when it is intelligently used under favorable circumstances, this new form of stimulant for plant growth will prove a very valuable and inexpensive substitute for chemical fertilizers.—Commercial America.

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## *INVESTIGATIONS AT THE LOUISIANA SUGAR EXPERIMENT STATION LABORATORY FOR 1904.*

A paper by Prof. C. A. Browne, Jr., read before the Louisiana Sugar Planters' Association, April 13, 1905.

### EXPERIMENTS WITH FEEDING MATERIALS.

Co-operative experiments have been carried out during the past year by the Experiment Stations with a large feed manufacturer relative to the improvement of rice bran as a cattle feed. Rice bran has a very high feeding value, when free from hulls, but our investigations show that the large amount of oil present causes this otherwise excellent food stuff to become rapidly rancid and unpalatable to cattle, and by its laxative action also produces a very loose condition of the bowels. By removing most of the oil these evil effects are done away with, and the keeping qualities of the bran much improved. A large factory has recently been erected at Crowley for the improvement of rice feeds along this line, and gives promise of becoming an industry of considerable importance.

In addition to the work upon the rice feeds, the composition of the various feeding stuffs which contain molasses, has been investigated. A partial report upon this subject was made at a Farmers' Institute held last year at Reserve; many other commercial feeds belonging to this class have been examined since then and a tabulation of a few representative analyses may not be out of place. In the work of analysis I was assisted by Mr. Verret.

A few words of comment are necessary regarding some of the above feeds. The commercial mixtures containing blood and molasses, many combinations of which are prepared in European countries, offer a supply of very digestible protein, but have the objection in a warm climate of sometimes undergoing rapid decomposition. A large sack of such a feed examined at the station laboratory was found to have fermented to such an extent that the material was almost putrid. Practical feeding tests were of course out of the question. Molasses has an antiseptic action when mixed with blood and the activity of the bacteria which cause putrefaction is largely suspended, provided that the feed is properly dried and that the amount of blood used is not excessive. Manufacturers desiring to prepare blood-molasses mixtures for tropical and semi-tropical climates should bear these facts in mind and reduce the percentage of blood below the danger limit.

Some criticism is necessary regarding the material used as an absorptive agent for the molasses in the case of several of the feeds examined. In a number of instances the very poorest quality of miller's waste was used, as was shown by the presence of the seeds of many noxious weeds. Prof. Dodson, who made an examination of these, detected such pests as smart weed, dock, cockle, and others too numerous to mention. The materials thus employed came from the flouring mills of the North and the importation of such trash offers a most ready means of scattering and disseminating weeds. Among other filling materials of poor quality may be mentioned mill sweepings, corn cob waste from pipe factories, and ground up rice hulls, (star bran); the latter product has absolutely no feeding value and evidence is at hand showing that it often causes injury to animals. Unscrupulous manufacturers make use of molasses in preparing feeds not so much for its food value, as for the reason that molasses serves to conceal

| | Blood Cereal, Molasses. | Corn, Oats, C. S. Meal, Molasses. | Corn, Oats, etc., Molasses. | Extracted Rice Bran, Molasses. | Molascuite Bagasse Molasses. |
|---|---|---|---|---|---|
| Moisture | 15.38 | 11.90 | 12.23 | 8.40 | 13.98 |
| Fat | 1.11 | 3.15 | 2.30 | 0.83 | 0.90 |
| Ash | 9.52 | 6.27 | 7.79 | 9.70 | 5.11 |
| Fiber | 12.98 | 14.30 | 12.78 | 13.00 | 5.64 |
| Protein | 16.13 | 12.75 | 6.41 | 14.00 | 1.94 |
| Sugars | 15.01 | 21.65 | 19.43 | 5.50 | 55.94 |
| Other carbohydrates, etc | 29.87 | 29.98 | 39.06 | 48.57 | 16.49 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

almost every sort of low grade product that may be used as a filler.

One of the very best materials that can be used as an absorptive agent for molasses is bagasse, and an analysis is given in the previous table of a sample of "molascuit" which consists of about 20 per cent. of the pithy part of bagasse and 80 per cent. molasses. The rind of the cane is not so well adapted as the pith for mixing, since it has only one-sixth the absorptive power of the pith, and is besides much harder to digest.

Louisiana manufacturers could greatly improve upon "molascuit," which is deficient in protein, by making an addition of cotton seed meal to the bagasse and molasses. The manufacture of such feed should recommend itself as a paying enterprise, as it offers a ready and profitable means for the disposal of our by-products.

## THE COMPOSITION OF LOUISIANA MOLASSES FROM DIFFERENT SUGAR HOUSES.

Before leaving the subject of molasses, it might be well to mention some investigations that have been conducted during the past year upon the chemical nature of molasses from various sugar houses in the State; our purpose having been to see to what extent the composition of our molasses is affected by the difference in the process of manufacture. A few of the results are given below, the analytical part of this work having been largely performed by Mr. Halligan: (See Table II below.)

Samples 3 and 4 represented final third molasses and it will be observed that the lowest purity recorded is about 35. This is a very good exhaustion for a molasses, though reports are frequently circulated of purities being reduced to 20, or under. Such reports may result from a fermentation or inversion of the sucrose in the molasses, but are usually the consequence of a faulty method of calculation. Very frequently the Brix of the molasses by double or triple dilution is taken instead of the total solids and the direct reading in the polariscope instead of the sucrose by Clerget; such a procedure will necessarily reduce the purity below its true value. In sample 3 for example, the Brix by double dilution was 85.23 and the polarization 16.00; using these values we obtain a purity of 18.77 which is over 16 points below the actual figure.

A study of the results in table II shows that the process of manufacture has much to do with the differences in composition. The open kettle molasses being less exhausted than the other grades, has naturally more sucrose and less impurities such as gums, acids, ash, amids, etc. The diffusion molasses, on the other hand, has a larger percentage of impurities owing

TABLE II. ANALYSES OF MOLASSES.

TABLE II—ANALYSIS OF MOLASSES.

| | 1<br>Open Kettle | 2<br>Diffusion Com. Cent. | 3<br>Mill Com. Cent. | 4<br>Mill Com. Centrif. | 5<br>Mill Carbonation |
|---|---|---|---|---|---|
| Sucrose Double Pol. | 50.83 | 34.83 | 26.89 | 31.2[illegible] | 37.06 |
| Dextrose | 8.30 | 9.72 | 14.27 | 12.53 | 13.76 |
| Levulose | 5.08 | 13.68 | 15.58 | 15.00 | 14.71 |
| Albuminoids | 0.11 | 0.50 | 0.39 | 0.31 | 0.04 |
| Amids | 0.58 | 2.50 | 2.49 | 1.38 | 1.54 |
| Free Acids | 0.73 | 2.35 | 1.74 | 2.01 | 1.18 |
| Combined Acids | 2.17 | 2.14 | 4.76 | 3.16 | 2.57 |
| Gums | 0.57 | 2.47 | 3.16 | 2.41 | 2.95 |
| Lime (CaO) | 0.19 | 0.73 | 1.43 | 0.74 | 0.67 |
| Phos. Acid (P2 O5) | 0.33 | 0.84 | 0.19 | 0.84 | 0.06 |
| Sulph. Acid (SO3) | 0.19 | 1.00 | 1.55 | 1.27 | 0.78 |
| Other Ash Constituents | 2.82 | 8.81 | 5.96 | 7.70 | 4.80 |
| Total | 71.90 | 79.57 | 78.41 | 78.60 | 80.12 |
| Total Solids | 72.14 | 78.57 | 76.94 | 79.98 | 79.81 |
| Coefficient of Purity | 70.46 | 44.33 | 34.95 | 39.07 | 46.43 |

to the greater extraction of these ingredients from the bagasse. The effect of liming upon the different samples is very pronounced, those which have received the heaviest treatment being the highest in gums and combined acids. A large part of those compounds which we designate as gums and acids in molasses do not come from the cane, but are the result of the action of lime upon the glucose of the juice.

In addition to liming and sulphuring, many planters supplement their clarification by a treatment with phosphoric acid. This procedure influences the composition of the molasses to a marked degree. A part of the lime is removed as insoluble phosphate, and the percentage of phosphoric acid in solution usually increased. The phosphoric acid occurring naturally in cane molasses in Louisiana is never greater than 0.25 per cent. and when this limit is exceeded we have a certain indication that phosphoric acid in some form has been used in the process of clarification. In some cases a dilute solution of phosphoric acid is used for washing the sugar in the centrifugals and this has been known to injure the appearance of high grade molasses by rendering it turbid through precipitation of lime phosphate.

THE SOLIDS NOT SUGAR IN CANE MOLASSES.

In connection with the foregoing investigations, a large amount of work has been done towards identifying the organic substances not sugar, which occur in our cane molasses. The number of these substances is legion, almost, and the difficulties in the analytical work are so great that progress in this direction has been somewhat slow. The organic bodies not sugar in molasses are made up largely of gums, nitrogenous compounds, acids, and caramel-like substances.

The different gums which we have identified may be divided into three classes. 1. Those derived naturally from the cane, such as xylan, araban and galactan. 2. Those resulting from fermentation changes in the juice, syrup or molasses, such as dextran, mannan, and cellulan. 3. Those produced by the action of the clarifying agents during the process of manufacture. This third class of gums embraces a number of dextrinoid bodies which seem to be largely the result of liming upon the glucose of the juice. Their exact chemical nature is hard to define, for I have been unable thus far to isolate them in a pure condition. Some of them are of an acid nature (melassic and Saccharic acids) and would therefore strictly come under the group of acids.

The nitrogenous compounds make up another important family of substances. The following table will show the distribution of the N among the various constituents in a sample of normal cane molasses. In the analytical part of this work I was greatly aided by Mr. Hardin:

TABLE III.

| | |
|---|---|
| Nitrogen in Albuminoids (Peptones) | 0.0153 per cent. |
| Nitrogen in Ammoniacal form | 0.0147 per cent. |
| Nitrogen in Nitrates | 0.0370 per cent. |
| Nitrogen in Amido acids (Aspartic) | 0.1774 per cent. |
| Nitrogen in Amido—acid—amids (Asparagin, etc.) | 0.0672 per cent. |
| Nitrogen in Nitrogenous bases (Xanthine, etc.) | 0.1113 per cent. |
| Nitrogen in other forms | 0.0441 per cent. |
| Total | 0.4670 per cent. |

Among the organic acids which we have found in the various molasses studied may be mentioned fermic, acetic, lactic, the amido acids mentioned above, and a whole series of fatty acids from butyric acid up. Some of these acids mentioned are always present, others are only of exceptional occurrence. These acids, like the gums, may be divided into three classes according to their origin. First, those derived from the cane; second, those formed during the process of manufacture; third, those produced by fermentation.

In addition to the above well defined group of substances, there is another class of miscellaneous bodies, such as glycerine, mannite, lecithine, and cholesterine, which we have found of occasional occurrence. To enter into a fuller account of the various substances enumerated would exceed the limits of our paper, and we are obliged to pass them over with a bare mention. I would, however, before leaving this topic, like to speak of two or three other compounds simply for the purpose of showing what unexpected substances one may occasionally meet with in cane molasses.

Several years ago a French chemist, Grimbert, discovered among the products of a certain fermentation a compound which he termed acetyl-methyl-carbinol, CH3 CO-CHOH-CH3. About this time, and while unfamiliar with the discovery of Grimbert, I found the same identical compound in a sample of fermented vinegar in Pennsylvania, and gave it a different name, dimethylketol, which was the term originally applied to this compound by the German chemist Pechmann, who had first made it synthetically. Last year while working upon a sample of sour molasses, I was somewhat surprised to meet again this old familiar compound. The instance is interesting for it shows how a substance known for years only as a laboratory product, may prove to be of general occurrence in nature. The compound, I should state, resembles glucose in many of its properties; from its strong reducing action on Fehling solution it may, if present in large amounts, introduce an error into the ordinary glucose determination. Fortunately, however, its presence in molasses seems to be exceptional and no serious troubles need be apprehended from its occurrence.

As other examples of peculiar substances obtained from molasses, I will mention several interesting products found in the scums of our hot-room molasses. We have noticed now for the past few years in molasses left over in the hot-room, the gradual formation during the summer time of a thick blanket of yellowish-white scums. A large quantity of this scum was collected and after washing to remove molasses was found to consist of a white flocculent mass resembling the pulp of paper. The product thus obtained, yielded upon analysis large quantities of *chitine*, a substance well known as the principal constituent of the shells of crabs, lobsters, crawfish and other crustaceans. The chitine obtained from the scums upon treatment with hydrochloric acid yielded large quantities of glucosamine hydrochloride, a beautiful white crystalline compound, having a specific rotation in the polariscope of 70.45, a little above that of cane sugar.

In addition to chitine, the molasses scums contained a large quantity of fatty matter and the analysis of this showed it to have almost the same composition and characteristics as the fat of butter.

TABLE IV.

| | Fat from Molasses Scums. | Butter Fat. |
|---|---|---|
| | o | o |
| Melting point | 33° C. | 33.2° C. |
| Saponification value | 223.1 | 228.5 |
| Iodine absorption | 28.17 | 33.4 |
| Volatile Acid value (5 gms) | 30.4 | 28.3 |

Butter fat, as is well known, yields large quantities of butyric acid upon saponification and this property was shared to the same degree by the fat from the scums.

An analysis of the dried scums from the molasses showed the following percentage composition:

| | |
|---|---|
| Moisture | 10.00 per cent. |
| Chitine | 11.30 per cent. |
| Protein | 31.62 per cent. |
| Fat | 27.50 per cent. |
| Ash | 5.58 per cent. |
| Carbohydrates, etc. | 14.00 per cent. |
| Total | 100.00 per cent. |

Regarding the formation of these scums, I should state that they are of fungus origin and that the chitine, protein and fat in the above analysis are produced through biochemical processes by the metamorphosis of the sugars, amids, and other ingredients of the molasses. Such changes are necessarily attended by a marked deterioration in the molasses itself, as the following analysis of the surface molasses from an infected tank will show:

| | |
|---|---|
| Brix | 69.66 per cent. |
| Sucrose | 1.72 per cent. |
| Coefficient of purity | 2.47 per cent. |

The above analysis is an additional confirmation of what was said before regarding the purity coefficient. There are other factors besides crystallization which can exhaust our molasses of sucrose and this is a point we should bear in mind whenever we hear or read of phenomenally low purities.

## VII. THE FERMENTATION OF CANE PRODUCTS.

The deterioration of molasses through ferments of a fungus nature leads me to my next topic—that of the fermentation of cane products in general. This subject has engaged our attention a great deal during the past year. Over a dozen destructive organisms that thrive in our juices, syrups, molasses and sugars, have been studied and the losses caused thereby investigated. These organisms do us damage in several ways; they not only destroy sucrose but produce invert sugar, gums, acids and other products which interfere seriously with the work of clarification. This damage is usually produced after the juice is extracted. The great majority of micro-organisms are unable to work much injury within the body of sound canes, principally for the reason that the living plant generates an important class of bodies called enzymes, some of which, as we have found, on exposure to the air produce by oxidation toxic products which prevent the invasion of bacteria through parts in any manner bruised or injured. This oxidizing action is perceptible by the reddish brown discoloration which always takes place upon the exposed tissues of a living cane, as in the pathway of the borer or upon the parts of the leaf-sheath infected by the Pou-a-poche.

It can be readily seen that this provision of the plant in protecting itself against disease is of paramount importance. When the cane is killed, however, as by a freeze, this power is lost; a discoloration is evident around the frozen parts owing to the exposure of these to the air, but the formation of toxic products to meet the extreme exigencies of the case does not go on anew. Hordes of bacteria invade the body of the cane through the cracks and dead eyes and within a few days, especially if the weather turns warm, the cane has fermented to such an extent that it is worthless for milling. * *

While fermentation is fortunately of exceptional occurrence within the body of the cane, it may take place at any time upon its surface. An example of this was presented to our attention last season with canes infected by the Pou-a-poche. This insect feeds upon the inner surface of the leaf-sheath causing the reddish discoloration already spoken of, which being visible from the outside may be regarded as a sure indication of the presence of this pest. The juice, which exudes from the wounded surface, runs down upon the stalk and undergoing fermentation leaves a deposit of gummy matter. This gum, which has a sweetish taste and a peculiar characteristic odor, was found to consist mostly of dextran with a considerable amount of dextrose; a little mannite, and traces of sucrose were also present.

Another important bearing, which the question of fermentation has, is that pertaining to the manufacture of cane syrup. There is probably no problem of more vital importance facing the manufacturer of syrup than that of marketing his product in such a way that it will withstand fermentation, and of the numerous inquiries which come to the station about syrup making, more are asked regarding the best methods of preventing fermentation than any other subject.

In this connection, we may say first of all that the use of chemical preservatives is precluded by the pure food regulations of the different States. Sterilization by heating under properly regulated conditions is a safe and most effective method, but does not seem to give satisfaction in every case. One complaint, which does not appear to me to have much foundation, is that sterilization injures the flavor of the syrup, and one large dealer in the North has informed me that even pasteurization, which requires only a temperature of 160 degrees F., spoils the taste of fine syrup. These temperatures of pasteurization and sterilization are exceeded, however, in the boiling of the juice for syrup, so that the objection of spoiling flavor may be dismissed as having but little force.

Another complaint of sterilization is that it does not always sterilize; that casks, jugs, bottles and other containers, are often found afterwards to be badly contaminated with moulds and other ferments. The difficulty in this case is due to the use of improperly disinfected containers. In preserving wines in European countries it is customary to disinfect all casks, etc., with sulphur fumes before filling. This destroys all spores of microorganisms, particularly those of the more resistant moulds which are the hardest to kill. The same method could be employed to advantage in our syrup industry. If all bottles, jugs, casks, etc., together with their corks and bungs, are well cleaned, steamed and disinfected with sulphur fumes, then filled at once with the hot syrup, immediately corked and sealed, there would be no trouble with fermentation * * * * * *

Another very serious loss in our sugar industry resulting from fermentation is the deterioration of raw sugars during shipment or in storage. As an example of what may occur in this line, allow me to mention the case of a number of Cuban sugars polarized at the station last spring and again several months later in the fall:

TABLE VII.

| No. | Polarization Spring. | Polarization Fall. | Loss. |
|---|---|---|---|
| 1 | 95.9 | 91.5 | 4.4 |
| 2 | 93.9 | 91.1 | 8.8 |
| 3 | 94.7 | 91.2 | 3.5 |
| 4 | 96.2 | 89.0 | 7.2 |
| 5 | 96.8 | 90.7 | 6.1 |
| 6 | 95.0 | 91.2 | 3.8 |

The above sugars were very sour and had perceptibly darkened in color at the time of the second polarization. Bacteriological tests showed the presence of numerous species of bacteria, one kind especially abundant when transplanted to sterilized cane juice proved very destructive, causing at the same time a dark coloration and giving rise to products of an acid nature. This organism, an aerobic form, appeared to be the chief cause of the deterioration in the Cuban sugars, and its action upon cane products is at present being studied.

The statement is frequently made that yeasts and bacteria cannot thrive in such a dense medium as molasses or in a solid material like sugar, and this in a certain sense is true. The fermentation of molasses, however, is confined to the surface and the deterioration of raw sugars takes place not within the grain, but upon the exterior which is covered with a thin coating of molasses. Owing to its hygroscopic nature the surface of molasses absorbs moisture readily from the air and this diluted film becomes a very suitable medium for the growth of micro organisms. The deterioration under these conditions is necessarily much slower than it would be in a juice or syrup, yet when the process extends over a considerable period of time, its consequences become very marked. If sugars intended for storage or long shipment were thoroughly dried, the losses from deterioration would be greatly minimized.

## VIII. EFFECTS OF TEMPERATURE UPON THE POLARIZATION OF RAW CANE SUGARS.

Differences in the polarization of raw sugars between points of shipment and of entry are not produced entirely by fermentation changes; they may also be the result of differences in the temperature of polarization. The study of this point has attracted the attention of a great many chemists of late, and it is now generally conceded that the polarization of pure sucrose will vary over half a per cent. with a difference of 20 deg. C., between the temperatures of the two readings—the lower the temperature the higher the polarization. The error in polarizing sugars at a tropical port such as Havana and at a northern port such as Boston, may therefore be considerable, especially during the winter months. To remedy this error tables have been constructed by means of which all readings may be corrected to a constant temperature of polarization. I have attempted to use a table of this description in the polarization of cane sugars at the experiment station and have come to the conclusion that while the table may be valuable in polarizing refined sugars and raw beet products, it will not answer at all in the polarization of raw cane sugars.

The reason for this is not difficult to find. We have in raw cane sugars in addition to sucrose, appreciable amounts of the reducing sugars dextrose and levulose; now while the polarization of dextrose is but very little effected by change in temperature, that of levulose is very decidedly influenced, more so than that of any other sugar ,and, what is of most importance, this temperature influence of levulose effects the polarization in an opposite way to the change in the rotation of sucrose. When polarizations are made at different temperatures, those opposing influences may nearly neutralize one another as in the case of the higher grade of raw sugars, or, as happen with low grade products, the effect of the levulose may more than counterbalance the sucrose variation, with the result that the sugar polarizes considerably more at the higher temperature, instead of lower as is the case of refined sugars.

To illustrate these points more clearly I will give in the following table, first, the polarizations of four raw sugars at 5 deg. C., second, the calculated polarizations at 20 deg. C., as determined by the table of sucrose corrections, third, the calculated poralization at 20 deg C., corrected for the variation of both sucrose and levulose, and fourth, the actual polarization at 20 deg. C.

The figures in column III are very much closer to the actual polarizations than those in column II, which show in some cases a variation of nearly a per cent. In fact with sugars of the above class it is far better to do without the table of

TABLE VIII.

| GRADE OF SUGAR. | Dextrose | Levulose | Polarization 5 deg. C. | Calculated Polarization 20 deg. C according to table of sucrose corrections. | Calculated Polarization 20 deg. C. corrected for Suc. and levulose. | Actual Polarization 20 deg. C. |
|---|---|---|---|---|---|---|
| Fancy Seconds .................... | 1.99 | 1.79 | 95.94 | 95.47 | 95.70 | 96.06 |
| Choice Seconds .................. | 2.41 | 2.37 | 89.78 | 89.38 | 89.68 | 89.87 |
| Prime Seconds .................... | 4.22 | 4.74 | 80.88 | 80.50 | 81.10 | 81.32 |
| Common Seconds ................. | 6.53 | 6.71 | 74.17 | 73.82 | 74.67 | 74.73 |

(Sucrose corrections subtracted and levulose corrections added; levulose correction equals .0084 x % levulose x difference in temperature of readings.)

sucrose corrections, as in every instance we increase instead of diminish the error of our reading.

The results expressed above shows, first, that a falling off in the polarization of raw sugars between ports in tropical and temperate latitudes may be due to differences in the temperature of polarization as well as to deterioration, and, second, that tables for correcting polarizations to a standard temperature, based upon variations in the rotation of sucrose alone, are of no value in the polarization of raw cane products. These observations hold, however, only for single polarization, for if the sugars are double polarized, as by the Clerget method, the levulose error is entirely obviated.

## IX. PHYSICAL EXPERIMENTS UPON THE MATURING OF CANE.

Last year we reported experiments upon the rate of maturing in our home cane. This year similar experiments have been conducted with other varieties, particular attention having been paid to the chemical changes which take place in the process of growth and ripening. Over fifty complete analyses of canes, both plant and stubble, have been made. We can not present a tabulation of all these results or even enter into a full discussion of them here, but a few general conclusions of the work may be admissable.

First of all, a comparison of the figures for the seasons of 1903 and 1904 shows the very marked influence of weather conditions. This can best be seen from the following figures, which I have condensed into tabular form from analyses of juice from stubble canes (Louisiana Purple) at different periods of growth:

The results for the two years show but little variation up to the middle of September, after this date the canes of 1903 increased considerably faster in sucrose, and this increase continued until the end of the season, when it exceeded 3 per cent. The average daily temperature and rainfall for the two years were also about the same during June, July and August; for the remaining months of the year, however, the conditions were very unlike. September, October, November and December of 1903 showed daily average in temperature of 7, 3.3, 6.3, and 9.4 degrees respectively lower than the corresponding months of last year; 1903 also showed a deficiency in rainfall of 2.00, 0.39, and 1.27 inches for the months of September, October and November. These conditions for year before last were very adverse for the growth of cane, yet hastened the ripening to an extent rarely attained in Louisiana. On the other hand, the unusually warm weather of last fall, together with favoring rains, promoted the growth of canes even into December, but retarded the ripening. The tonnage was high, but the sucrose content low. These differences in

| | Aug. 1. | Sept. 1. | Oct. 1. | Nov. 1. | Nov. 15 |
|---|---|---|---|---|---|
| **—1903—** | | | | | |
| Sucrose | 2.70 | 5.97 | 11.27 | 13.60 | 15.86 |
| Glucose | 3.80 | 3.68 | 2.51 | 1.02 | .63 |
| Purity | 36.00 | 57.02 | 76.72 | 87.85 | 92.10 |
| **—1904—** | | | | | |
| Sucrose | 2.35 | 5.13 | 8.04 | 9.13 | 12.00 |
| Glucose | 4.04 | 3.75 | 3.55 | 2.82 | 1.66 |
| Purity | 32.28 | 52.35 | 66.61 | 71.55 | 80.53 |

The weather conditions for the two years in question during the growing season were as follows:

| | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|
| Average daily temperature F., 1903 | 82.8 | 82.1 | 77. | 67.9 | 58. | 49. |
| Average daily temperature F., 1904 | 80.9 | 84.1 | 84.2 | 71.2 | 64.3 | 58.4 |
| Total rainfall inches, 1903 | 5.55 | 5.98 | 1.27 | 0.36 | 0.23 | 3.89 |
| Total rainfall inches, 1904 | 6.47 | 5.75 | 3.24 | 0.75 | 1.50 | 3.02 |

conditions naturally made themselves very noticeable in the sugar house, owing to the much lower purities of the juices and the relatively larger amount of water requiring evaporation.

A comparison of the analyses for the four different varieties, D. 74, D. 95, Purple and Striped, has developed a few general facts of interest. On each of the dates of analysis from August 1, up to the harvesting, the stubble cane averaged in weight about 80 per cent. of the plant cane for first year stubble, and about 70 per cent. for second year stubble. The stubble canes, on the other hand, at every analysis were all richer in fiber and sucrose and lower in glucose than the plant canes, the second year stubble exceeding the first year in these respects.

There is of course a physiological explanation for these differences. In stubble cane we have a partially dwarfed condition, and according to a well established law, when growth is checked, maturation is hastened. Exactly the same effect is produced by the non-fertilization of cane. Canes grown upon the non-manured plats at the Sugar Experiment Station average much less in weight but are higher in sucrose than canes which have been fertilized. The stunted growth of our stubble cane is due very largely to the inability of the crop to secure a sufficient supply of plant food, particularly nitrogen; an indication of this is shown by the deficiency of the juices from stubble cane in mineral and in nitrogenous ingredients. An inspection of the following table will show this very clearly:

TABLE IX.

| | —D. 74— | | —D. 95— | | Purple | | Striped | |
|---|---|---|---|---|---|---|---|---|
| | Pl. | St. | Pl. | St. | Pl. | St. | Pl. | St. |
| Ash— | .47 | .41 | .40 | .33 | .36 | .30 | .34 | .28 |
| Nitrogenous bodies— | .20 | .07 | .18 | .08 | .17 | .09 | .19 | .09 |

The stubble juices show in every instance a decrease of nearly 20 per cent. in ash and over 50 per cent. in nitrogenous bodies. These facts explain why it is that the juice from the stubble canes contains less solids not sugar, than that from plant cane.

Analyses show that the deficiency of nitrogenous ingredients in stubble cane falls most largely upon the reserve supply of nitrogen or the amids. This will be seen from the following analyses made about October 1st.:

| | Albuminoids. | Amids |
|---|---|---|
| D. 74— | | |
| Plant | .07 | .17 |
| Stubble | .07 | .02 |
| D. 95— | | |
| Plant | .07 | .12 |
| Stubble | .05 | .02 |
| Purple— | | |
| Plant | .09 | .11 |
| Stubble | .06 | .02 |
| Striped— | | |
| Plant | .09 | .13 |
| Stubble | .06 | .02 |

To maintain the vital processes of the cane a certain amount of albuminoid matter (protoplasm) is indispensable and to keep this up the plant draws upon its stores of amids. An inspection of the table shows that with the stubble canes this reserve is almost completely exhausted and subsequent analyses showed no gain. With the plant canes, on the other hand, there is always a large surplus of amids, which is being continually added to during the entire period of growth.

There are a number of reasons for this partially starved condition of our stubble crops. Among the most important of these may be mentioned the partial exhaustion of fertility, directly beneath the roots, by the previous crop, the difficulties in securing good tilage and the very unfavorable points of growth. The most that can be done towards helping the situation is to cultivate as thoroughly as possible and to fertilize well with nitrogenous manures.

An apparent regularity observed in the ratio of fiber to sugars in many of the analyses, led us to thoroughly investigate the statement some times made that there exists a definite and fixed ratio between the fiber and sugar content of cane. It was soon evident, however, that attempts to establish any such ratio between fiber and sucrose were futile, as the proportions varied from 0.5 to 1.5 of sucrose to 1.0 of fiber. The relation between fiber and total sugars was somewhat more constant but by no means fixed, ranging from 1 to 1 in the early stages of growth to 1.6 of sugars to 1 of fiber at the time of milling.

In the study of the different varieties of cane great care must be exercised in making our experiments and comparisons under similar conditions. We are all of us familiar with the differences in the physical appearances of our canes, such as color, erectness, length of joint, etc.; somewhat less acquainted perhaps with the differences in chemical composition, such as sucrose, glucose, and fiber content; but how little do we yet know of those underlying and hidden physiological peculiarities—rate of assimilation, transpiration, and the like. A study of the latter phenomena might well repay investigation, for upon them are largely dependent whatever excellencies one variety of cane may have over another.

An interesting fact in the above connection is the matter of ash content. We have in the ash an imperfect yet a fairly comparative measure of the transpired water for each variety of cane, since the mineral matter in solution as it enters the plant from the soil, accumulates in proportion to the degree of evaporation from the leaf surface. I will give here a few results taken from analyses of juices made the middle of August, which is about the period of most rapid growth:

TABLE X.

| | D. 74. | D. 95. | Purple. | Striped. |
|---|---|---|---|---|
| Sucrose | 4.88 | 2.45 | 2.35 | 2.03 |
| Glucose | 3.24 | 2.87 | 4.04 | 4.26 |
| Ash | .48 | .41 | .40 | .34 |

The ash content is much higher in the juice of D. 74 than in any of the other varieties; D. 95 stands second, Purple third and Striped fourth. This is also their relative position in sucrose content: as regards reducing sugar the order is the reverse to this. From the above results, which hold true during the entire period of growth, we may conclude that of the several canes studied, the D. 74 is the most vigorous feeder, thus requiring upon poor soils a heavier fertilization; we may also say that the D. 74 has the greatest powers of assimilation and conversion, as is shown by the higher content in sugars and lower glucose ratio. The experiments upon the different varieties are to be continued during the present season and a more complete synopsis of the results will be presented later.

## Sugar Plantations, Cane Growers and Sugar Mills.

| ISLAND AND NAME. | | MANAGER. | POST OFFICE. |
|---|---|---|---|
| **OAHU.** | | | |
| Apokaa Sugar Co. | * | G. F. Renton | Ewa |
| Ewa Plantation Co. | * | G. F. Renton | Ewa |
| Waianae Co. | *** | Fred Meyer | Waianae |
| Waialua Agricultural Co. | * | W. W. Goodale | Waialua |
| Kahuku Plantation Co. | x* | Andrew Adams | Kahuku |
| Waimanalo Sugar Co. | ** | G. Chalmers | Waimanalo |
| Oahu Sugar Co. | x | F. K. Bull | Waipahu |
| Honolulu Plantation Co. | ** | J. A. Low | Aiea |
| Laie Plantation | x* | S. E. Wooley | Laie |
| **MAUI.** | | | |
| Olowalu Co. | ** | Geo. Gibb | Lahaina |
| Pioneer Mill Co. | x | L. Barkhausen | Lahaina |
| Wailuku Sugar Co. | **x | C. B. Wells | Wailuku |
| Hawaiian Commercial & Sug. Co. | x* | H. P. Baldwin | Puunene |
| Paia Plantation | x* | D. C. Lindsay | Paia |
| Haiku Sugar Co | x* | H. A. Baldwin | Haiku |
| Kipahulu Sugar Co. | x | A. Gross | Kipahulu |
| Kihei Plantation Co. | x* | James Scott | Kihei |
| **HAWAII.** | | | |
| Paauhau Sugar Plantation Co. | ** | Jas. Gibb | Hamakua |
| Hamakua Mill Co. | *x | A. Lidgate | Paauilo |
| Kukaiau Plantation | x | J. M. Horner | Kukaiau |
| Kukaiau Mill Co. | *x | E. Madden | Paauilo |
| Ookala Sugar Co. | **x | W. G. Walker | Ookala |
| Laupahoehoe Sugar Co. | *x | C. McLennan | Papaaloa |
| Hakalau Plantation | ** | Geo. Ross | Hakalau |
| Honomu Sugar Co. | **x | Wm. Pullar | Honomu |
| Pepeekeo Sugar Co. | **x | Jas. Webster | Pepeekeo |
| Onomea Sugar Co. | **x | J. T. Moir | Hilo |
| Hilo Sugar Co. | ** | J. A. Scott | Hilo |
| Hawaii Mill Co. | x | W. H. Campbell | Hilo |
| Waiakea Mill Co. | *x | C. C. Kennedy | Hilo |
| Hawaiian Agricultural Co. | **x | Wm. G. Ogg | Pahala |
| Hutchinson Sugar Plantation Co. | ** | Carl Wolters | Naalehu |
| Union Mill Co. | *x | H. H. Renton | Kohala |
| Kohala Sugar Co. | * | E. E. Olding | Kohala |
| Pacific Sugar Mill | x** | D. Forbes | Kukuihaele |
| Honokaa Sugar Co. | x** | K. S. Gjerdrum | Honokaa |
| Olaa Sugar Co. | xx | J. Watt | Olaa |
| Puna Sugar Co. | | | Kapoho |
| Halawa Plantation | x*x | T. S. Kay | Kohala |
| Hawi Mill & Plantation | †† | John Hind | Kohala |
| Puako Plantation | †† | W. L. Vredenburg | S. Kohala |
| Niulii Sugar Mill and Plantation | *x | Robt Hall | Kohala |
| Puakea Plantation | *x | H. R. Bryant | Kohala |
| **KAUAI.** | | | |
| Kilauea Sugar Plantation Co. | ** | A. Moore | Kilauea |
| Gay & Robinson | x*x | Gay & Robinson | Makaweli |
| Makee Sugar Co. | | G. H. Fairchild | Kealia |
| Grove Farm Plantation | x | Ed. Broadbent | Lihue |
| Lihue Plantation Co. | x | F. Weber | Lihue |
| Koloa Sugar Co. | x | F. McLane | Koloa |
| McBryde Sugar Co. | *x | W. Stodart | Eleele |
| Hawaiian Sugar Co. | x* | B. D. Baldwin | Makaweli |
| Waimea Sugar Mill Co. | * | J. Fassoth | Waimea |
| Kekaha Sugar Co. | x | H. P. Faye | Kekaha |

| KEY. | HONOLULU AGENTS. | |
|---|---|---|
| * | Castle & Cooke | (5) |
| ** | W. G. Irwin & Co. | (8) |
| *** | J. M. Dowsett | (1) |
| x | H. Hackfeld & Co. | (9) |
| *x | T. H. Davies & Co. | (8) |
| **x | C. Brewer & Co. | (6) |
| x* | Alexander & Baldwin | (7) |
| x** | F. A. Schaefer & Co. | (2) |
| x*x | H. Waterhouse Trust Co. | (2) |
| †† | Hind, Rolph & Co. | (2) |
| xx | Bishop & Co | (1) |